WELCOME TO
NASA APPLIED REMOTE SENSING TRAINING (ARSET)
WEBINAR SERIES

INTRODUCTION TO REMOTE SENSING FOR CONSERVATION MANAGEMENT

COURSE DATES: EVERY TUESDAY, MAY 5 – JUNE 2
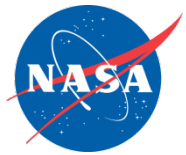## TIME: 12:00 – 1:00 PM EDT (GMT-04:00)
OR
10:00 – 11:00 PM EDT

Applied Remote Sensing Training

Course Structure

- One lecture per week – every Tuesday May 5 to June 2
  - 12:00 – 1:00 PM EDT (GMT-04:00) (Session 1)
  - 10:00 – 11:00 PM EDT (Session 2)

- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management

- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET Conservation Management webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com

- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

ARSET Conservation Management

https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management

Accessing the Recordings

You must register to access the recordings!
This is different from your webinar registration.

Your Course Instructors

- Cindy Schmidt (ARSET): cynthia.l.schmidt@nasa.gov
- Amber Kuss (ARSET): amberjean.m.kuss@nasa.gov
- Guest Speakers:
  - Walter Jetz – Yale University (week 3)
  - Jeff Cavner –University of Kansas (week 4)
  - Karyn Tabor – Conservation International (week 5)

General inquiries about ARSET: Ana Prados (ARSET) aprados@umbc.edu

Course Outline

Week 1

Overview of satellite remote sensing

Week 2
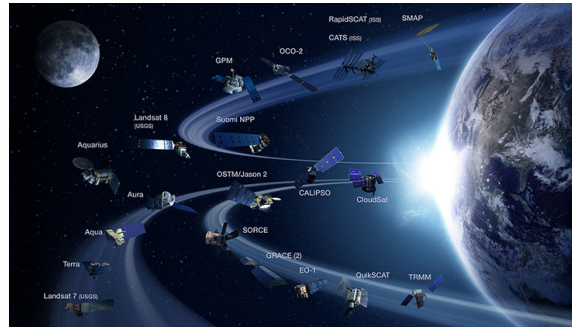
Platforms and sensors for conservation

Week 3
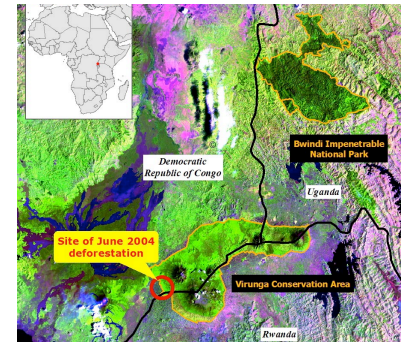
Habitat monitoring

Week 4
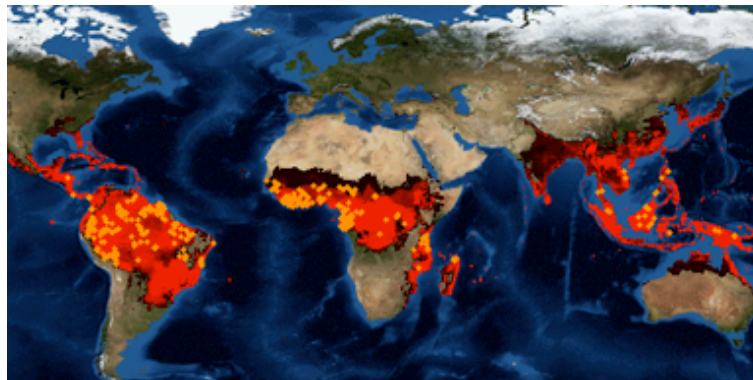
Animal movement

Week 5

Near-real time data

Week 4 Agenda

- ❑ Review of Week 3
- ❑ Overview of monitoring animal movement
- ❑ Remote sensing and animal movement
  - ❑ NDVI and Phenology
  - ❑ NDVI products
  - ❑ Examples
- ❑ Additional Resources
- ❑ Live demo
  - ❑ LifeMapper: Guest speaker Dr. Jeff Cavner, University of Kansas

Review of Week 3

Overview of Habitat Monitoring

- ❑ Used to assess the threat and conservation status of species and protected areas
- ❑ IUCN Red List key criteria:
  - ❑ Habitat extent
  - ❑ Fragmentation
  - ❑ Rate of Change

Image credit: E. De Merode

Land changes in the Virunga Conservation Area which provides habitat to approximately 380 mountain gorillas

Rapid deforestation occurred in June 2004 in the "Mikeno" section of the park
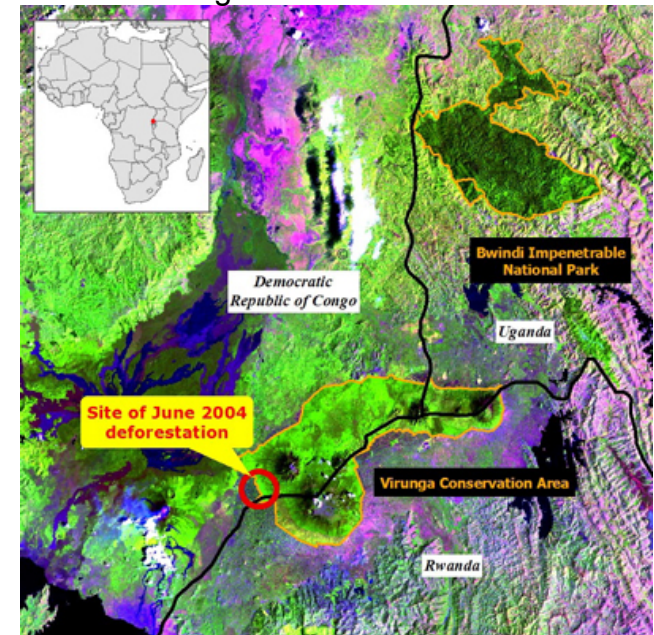
Image credit: Nadine Laporte/Tiffany Lin

Land Cover Mapping Basics

- Using Image Processing software, image classification involves using n number of bands, not just 2.

- You specify the number of land cover classes that are in your study area.

- There are many methods, but two common ones are Supervised and Unsupervised classification

Band 3 reflectance

Dry soil

water   vegetation

Band 4 reflectance
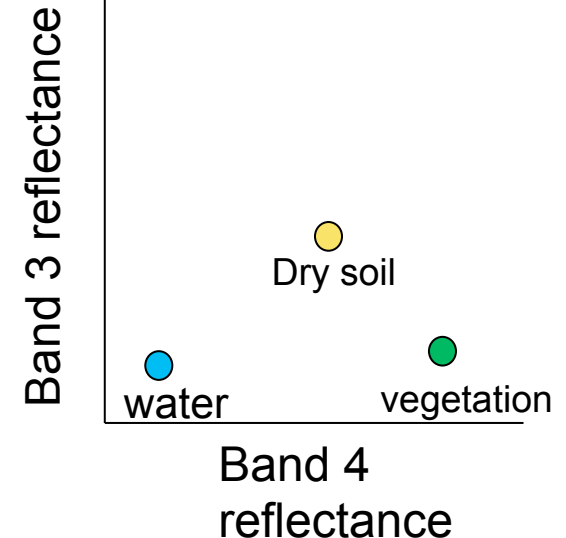
Legend:

Water

Vegetation

Dry soil

Global 1-km Consensus Land Cover

Tree Cover
100%
0%
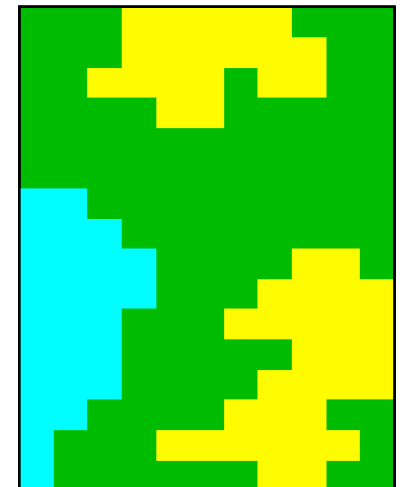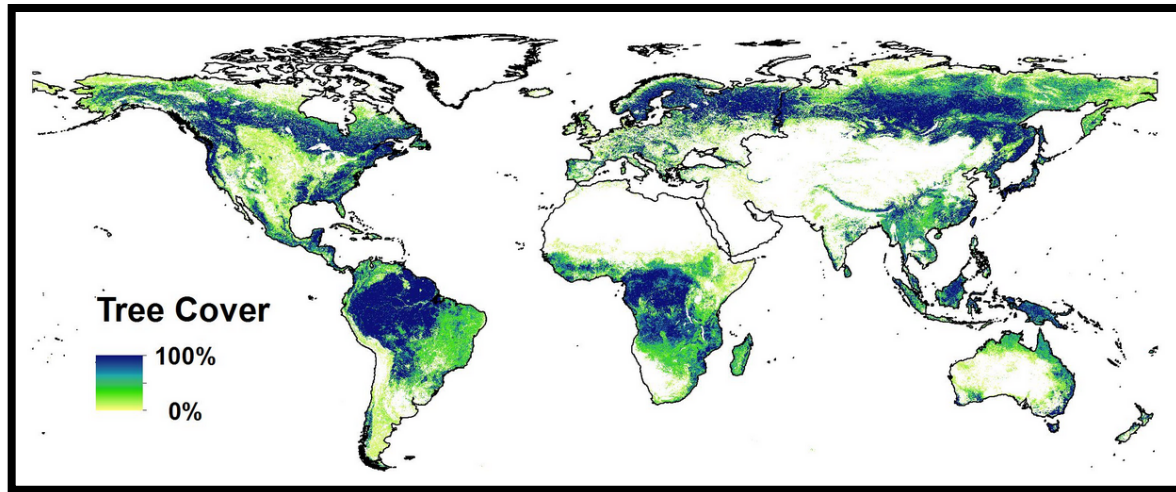
❑ Integrates multiple global remote sensing-derived land-cover products
❑ Includes 12 land cover classes at 1-km resolution
❑ Each land cover class is available as an individual layer for download in GeoTIFF format

www.earthenv.org/landcover.html

Global 1-km Consensus Land Cover
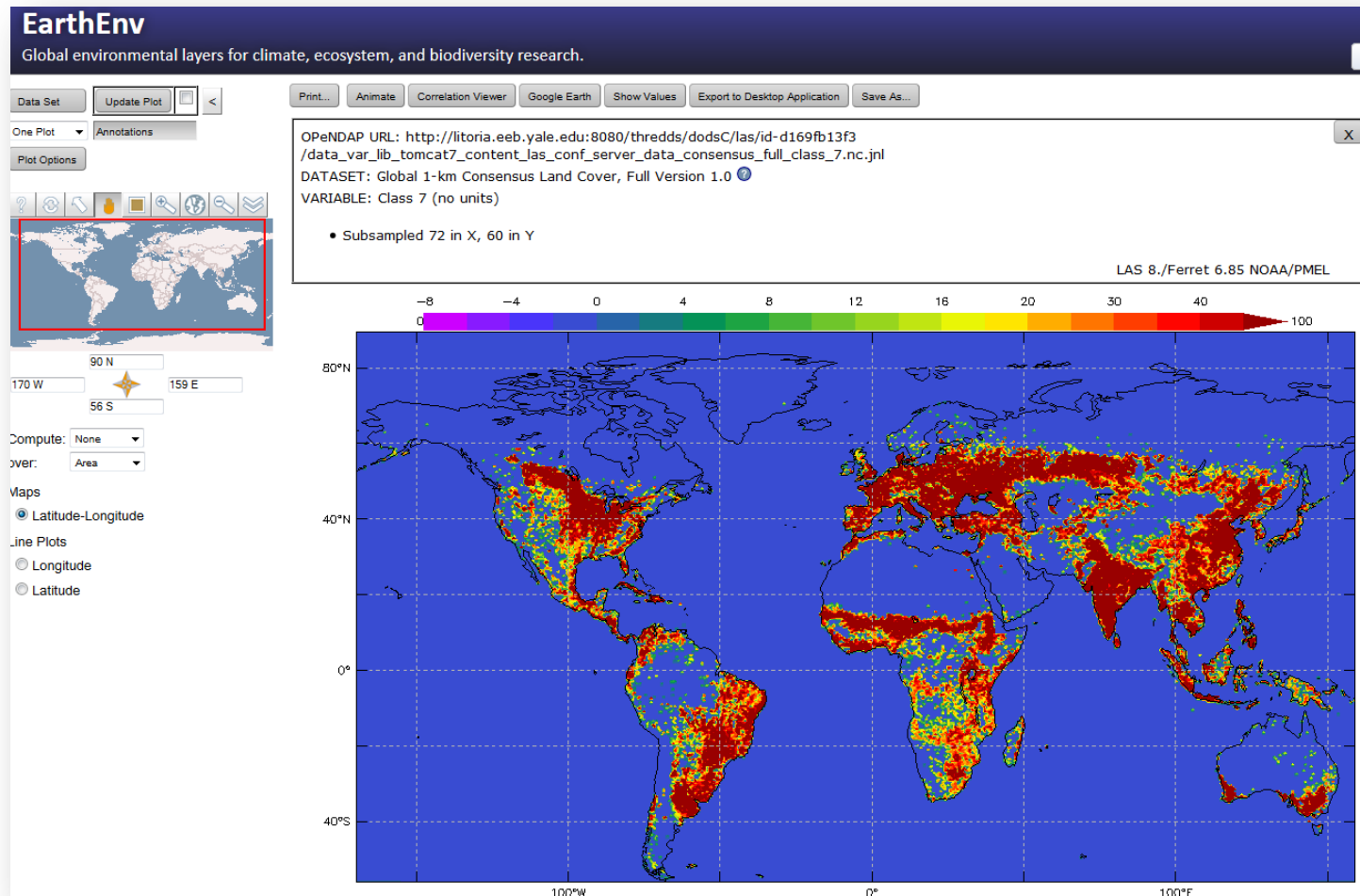
www.earthenv.org/landcover.html

Overview of Monitoring Animal Movement

Animal Movement

- ❑ Spatial and temporal animal movement patterns are a central focus of animal ecology.
- ❑ Four fundamental questions:
  - ❑ Why move?
  - ❑ How to move?
  - ❑ When and where to move?
  - ❑ What are the ecological and evolutionary consequences of movement?

Credit: Elizabeth Gordon

Serengeti wildebeest migration

Credit: tanzaniaonfoot.com

Animal Movement: Technologies

- ❏ Non-electronic tags (e.g. metal bands)
  - ❏ Requires capture and re-capture
- ❏ Radio or satellite tracking
  - ❏ Does not require re-capture
  - ❏ Sometimes have to follow animal, but sometimes not
  - ❏ Giving a complete, continuous picture of migration patterns

Credit: The Migratory Connectivity Project

Remote Sensing and Animal Movement: NDVI and Phenology

Remote Sensing and Animal Movement

- ❑ Animals interact with their environment at multiple spatiotemporal scales
- ❑ Remote sensing data can capture characteristics about the environment at different scales
- ❑ Animal locational data combined with remote sensing data can help determine why and where animals move

Credit: gallery.hd.org

This Burchells zebra is grazing on green grass in Addo Elephant Park, Eastern Cape, South Africa

Example: Wildebeest
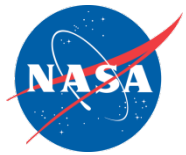
- ❑ Between December and April the wildebeest are on the short grass plains in the southern Serengeti

- ❑ In April and May the rains stop and the plains in the south and east of the Serengeti dry out. The herd then moves north and west where there is more grass and water.

- ❑ In June to July is transitional between rainy and dry season. The herds push further north towards the Maasai Mara.

- ❑ Between July and August many thousands of wildebeest move to the Maasai Mara.

- ❑ We can use remote sensing (precipitation and vegetation green up) to determine when and where the wildebeest will migrate.

Remote Sensing and Animal Movement

- ❑ Paper: "Opportunities for the application of advanced remotely-sensed data in ecological studies of terrestrial animal movement" Neumann et al., 2015, *Movement Ecology*
  - ❑ Studies of small-scale movement included data about land cover, infrastructure, and terrain
  - ❑ Studies of coarser-scale movement (e.g. migration) often used data on vegetation phenology, sometimes combined with climate, weather, and terrain data

Remote Sensing and Animal Movement

- ❑ Plants and animals have life cycles events that occur regularly every year that are dependent on temperature, precipitation and available sunlight.

- ❑ Vegetation information from satellite imagery is useful to study animal movement because plant phenology and vegetation productivity can often be linked to location of individuals.

Remote Sensing and Animal Movement

- ❑ RS information on vegetation productivity can be obtained through vegetation indices: Normalized Difference Vegetation Index (NDVI) or Enhanced Vegetation Index (EVI)
  - ❑ At coarser scales, shifts in relative NDVI distribution can explain movement to and from seasonal ranges
  - ❑ At finer scales, NDVI might explain the habitat choices of individuals at a particular point in time
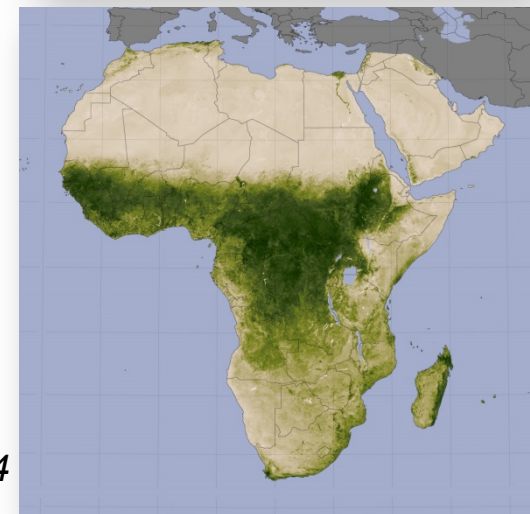
Vegetation changes in Africa from March 2004 (top) to September 2004 (bottom)

Source: www.earthobservatory.nasa.gov

What is NDVI?

❑ Normalized Difference Vegetation Index

   ❑ Based on the relationship between red and near-infrared wavelengths.

   ❑ Chlorophyll strongly absorbs visible (red)

   ❑ Plant structure strongly reflects near-infrared

Spectral Signatures
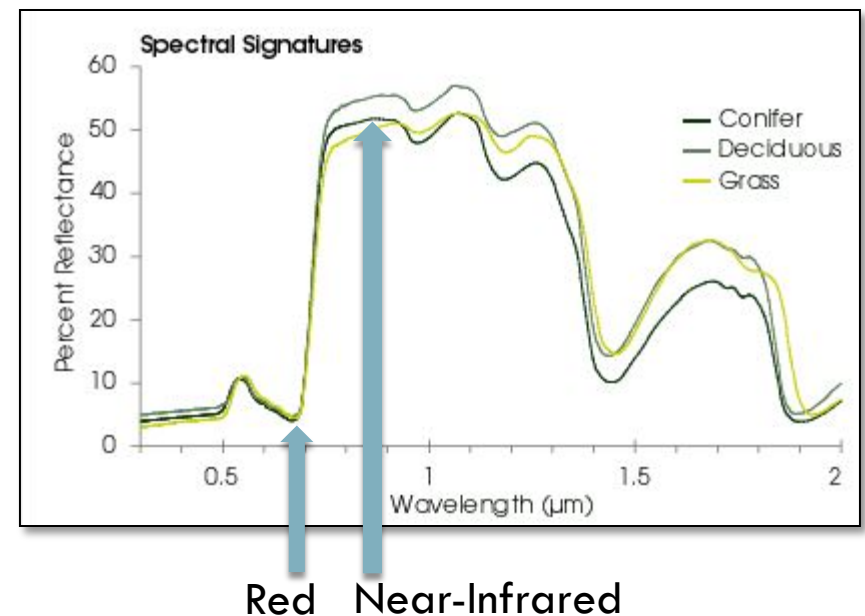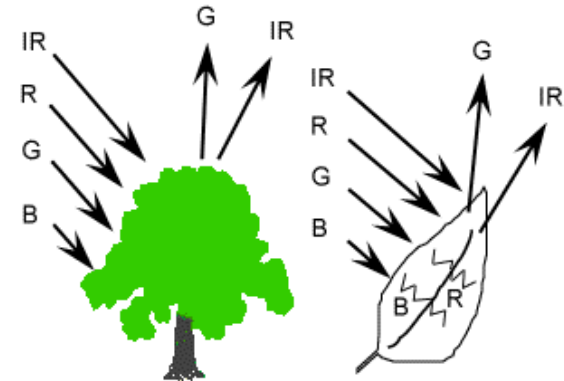
Red   Near-Infrared

What is NDVI?

- ❑ NDVI formula:
  <u>Near-Infrared – Red</u>
  Near-Infrared + Red

- ❑ Values range from -1.0 to 1.0
  - ❑ Negative values to 0 mean no green leaves
  - ❑ Values close to 1 indicates the highest possible density of green leaves.

$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72 \qquad \frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$
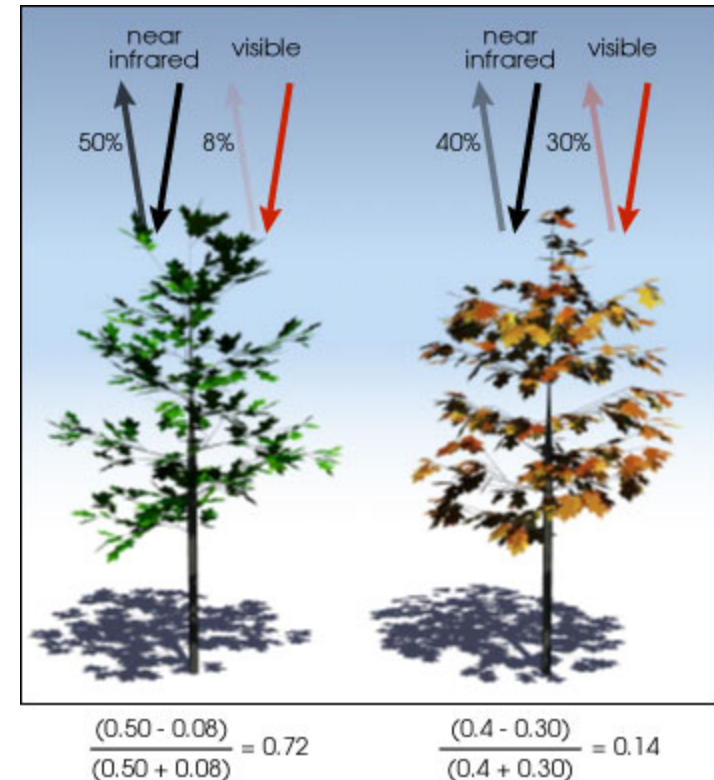
Image Credit: Robert Simmon

NDVI Example

This is Landsat NDVI image of the Panama Canal watershed

The darker green the area, the higher the NDVI value, the more green vegetation is present

This image was acquired in March 2000 during Panama's annual dry season.

Normalized Difference Vegetation Index (NDVI)

-0.1   0.1   0.3   0.5   0.7   0.9

Source: http://earthobservatory.nasa.gov

NDVI: Phenology

- Remote sensing is used to track the seasonal changes in vegetation
- Monthly NDVI images from MODIS or Landsat can be used to monitor phenology
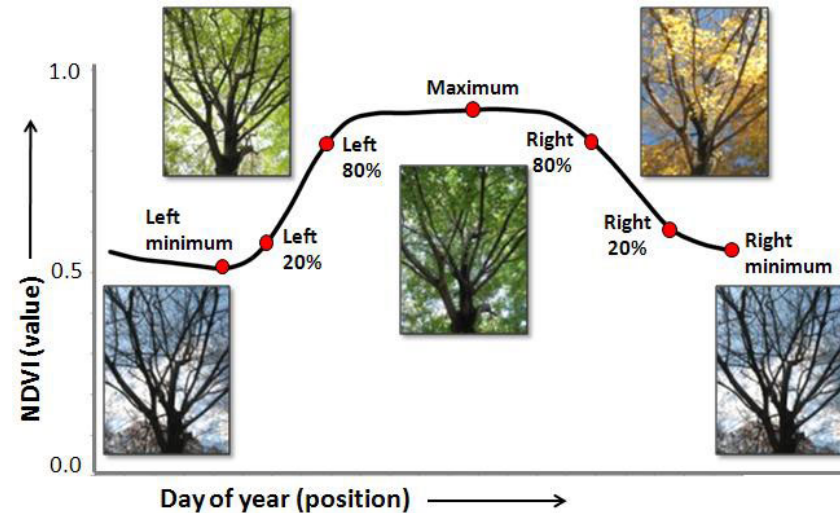
Credit: spacegrant.montana.edu

North America NDVI images in winter and summer

Remote Sensing and Animal Movement: NDVI and Phenology Products

MODIS Products

MODIS Name	Product Name	Spatial Resolution (m)	Temporal
MOD 09	Surface Reflectance	500	8-day
MOD 11	Land Surface Temperature	1000	Daily, 8-day
MOD 12	Land Cover/Change	500	8-day, Yearly
MOD 13	Vegetation Indices	250 – 1km	16 day
MOD 14	Thermal Anomalies/Fire	1000	Daily, 8-day
MOD 15	Leaf Area Index/Fraction of Absorbed Photosynthetically Active Radiation (FPAR)	1000	4-day, 8-day
MOD 16	Evapotranspiration		
MOD 17	Primary Production	1000	8-day, yearly
MOD 43	Bidirectional reflectance distribution function (BRDF)/Albedo	500-1000	16-day
MOD 44	Vegetation Continuous Fields	250	yearly
MOD 45	Burned Area	500	monthly

MODIS NDVI and EVI

Composite	Spatial Resolution	Terra	Aqua
16-day	250 m	MOD13Q1	MYD13Q1
16-day	500 m	MOD13A1	MYD13A1
16-day	1km	MOD13A2	MYD13A2
16-day	.05 deg (~5.5 km)	MOD13C1	MYD13C1
Monthly	1km	MOD13A3	MYD13A3
Monthly	.05 deg (~5.5 km)	MOD13C2	MYD13C2

http://reverb.echo.nasa.gov
https://mrtweb.cr.usgs.gov

What is EVI?

- Enhanced Vegetation Index (MOD13Q1) – only from MODIS
  - Maintains sensitivity over dense vegetation conditions
  - Uses the blue band to remove residual atmosphere contamination caused by smoke and sub-pixel thin clouds

Image credit: NASA Earth Observatory

MODIS Products

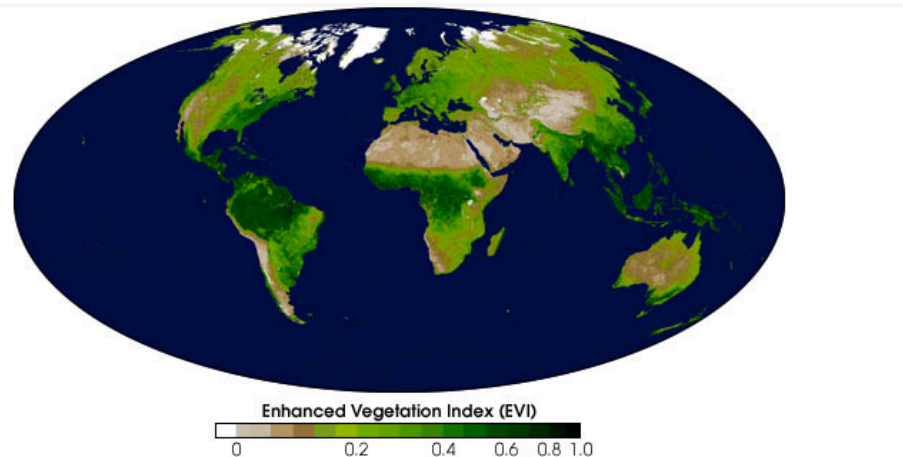| MODIS Name	Product Name	Spatial Resolution (m)	Temporal
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MOD 16	Evapotranspiration		
MOD 17	Primary Production	1000	8-day, yearly
MOD 43	Bidirectional reflectance distribution function (BRDF)/Albedo	500-1000	16-day
MOD 44	Vegetation Continuous Fields	250	yearly
MOD 45	Burned Area	500	monthly

MODIS Land Cover Dynamics (MCD12Q2)
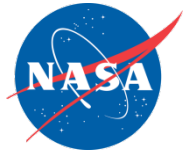
- ❑ MODIS Phenology (2001-2012)
  - ■ Start of season time/NDVI
  - ■ End of season time/NDVI
  - ■ Time of Maximum NDVI
  - ■ Length of growing season
  - ■ Maximum increase in canopy
  - ■ Photosynthetic activity across entire growing season
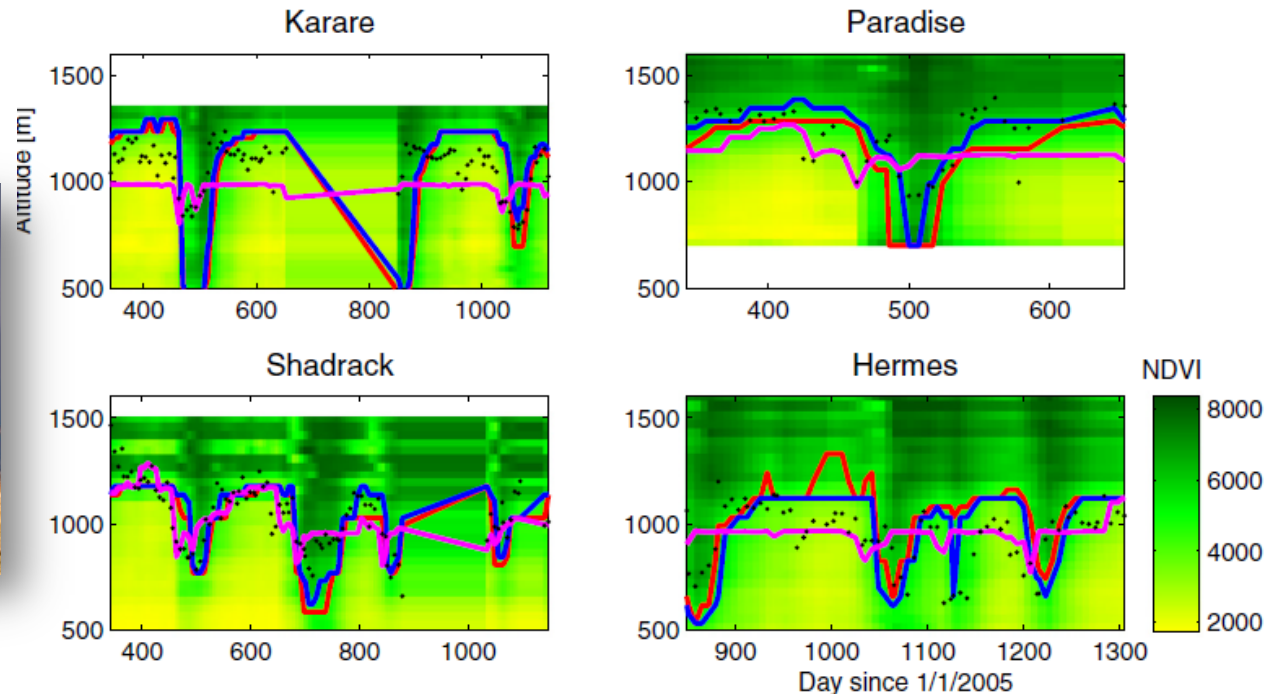

http://reverb.echo.nasa.gov
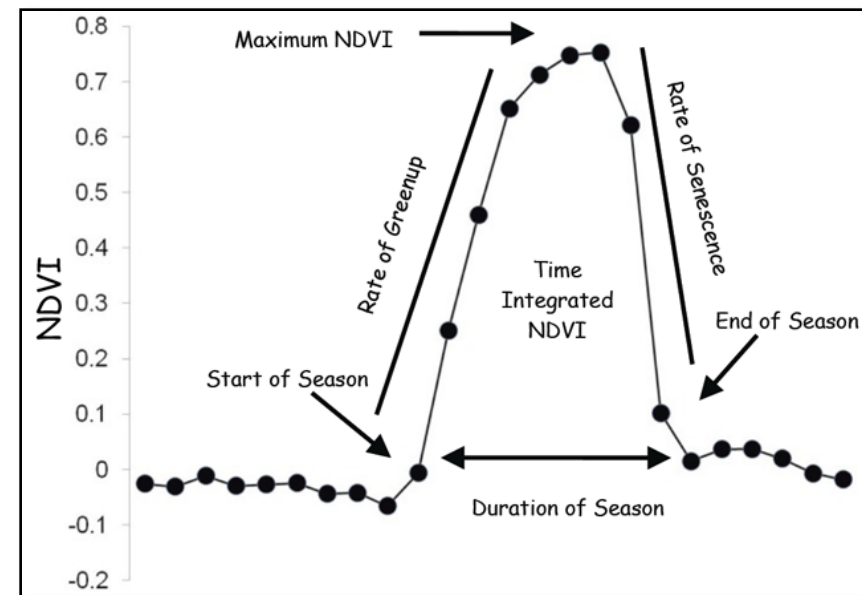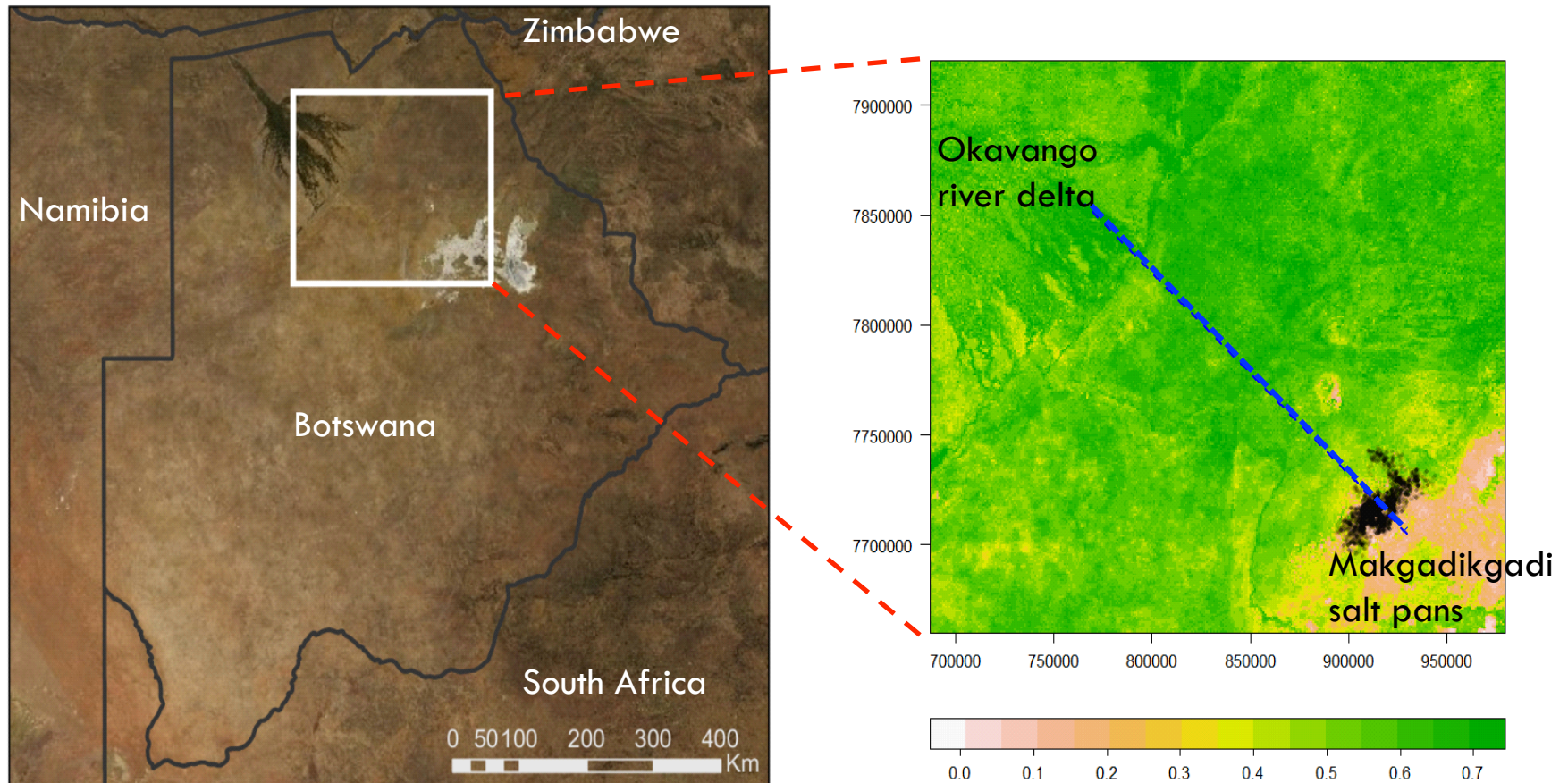
Some Examples

Use Case: Phenology and Elephants

❑ Bohrer et al. (2014) found that the elevational migration of individual elephants closely matched the patterns of greening and senescing of vegetation in their home range.
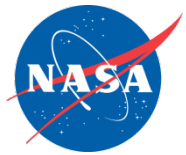
Use Case: Zebras at the Okavango Delta: Moving to greener pastures

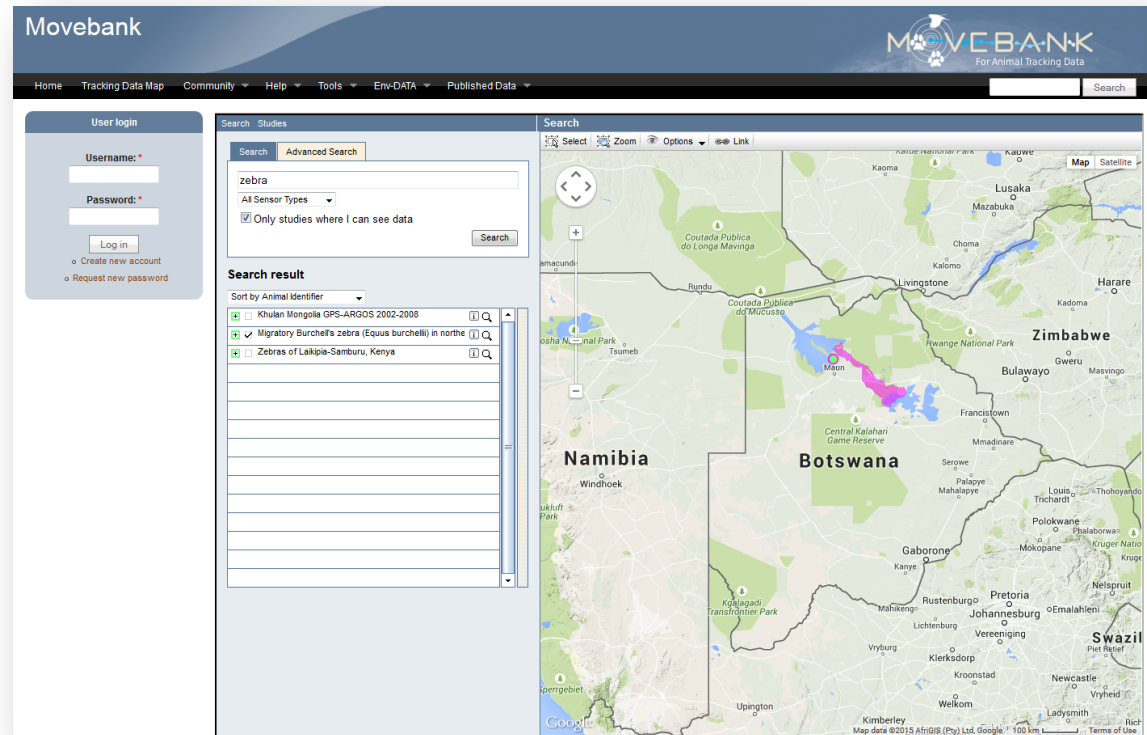Bartlam-Brooks et al. (2014), JGR

Movebank

□ Movebank is a free, online database of animal tracking data hosted by the Max Planck Institute of Ornithology.

  □ Helps animal tracking researchers to manage, share, protect, analyze and archive their data.

This shows the web interface for Movebank. This example shows migratory path of Burchell's zebra in northern Botswana.

http://www.movebank.org

Movebank: The Env-DATA System

- **Goals:**
  - To streamline the co-registration of animal tracking data with a diverse range of environmental variables
  - To allow scientists to examine relationships between animal movement and ambient atmospheric observations and underlying landscape
  - For more information and tutorials go to:

    http://youtube.com/movebank
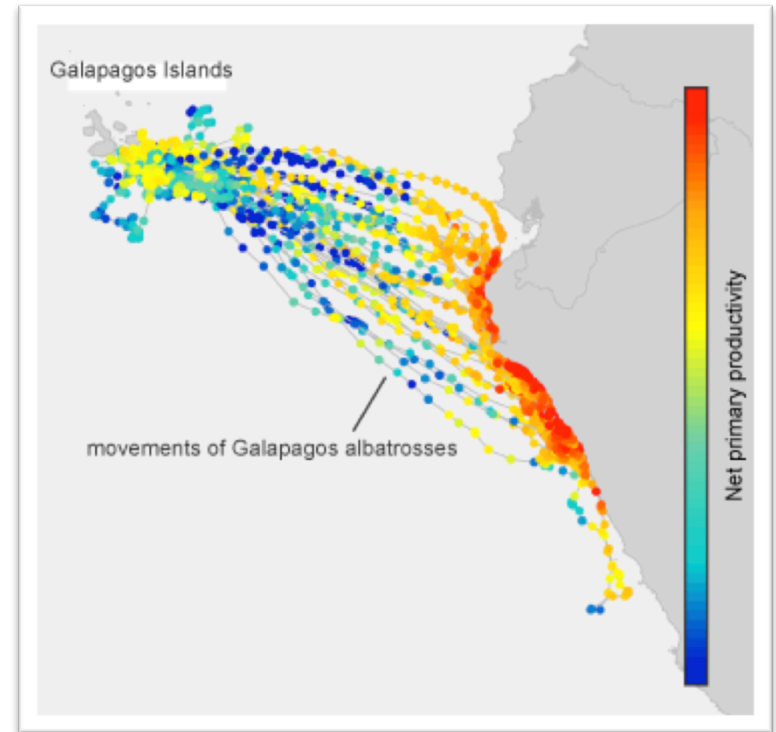
This image shows 8-day ocean net primary productivity annotated to tracks of Galapagos albatrosses

Movebank: The Env-DATA System

- ❑ Automate the acquisition of data from open web resources of remote sensing and weather data
  - ❑ 50 large global datasets (>4000 variables)
  - ❑ NASA, NOAA, USGS, NCEP/NCAR and ECMWF weather reanalysis datasets
  - ❑ Complete list: https://www.movebank.org/mode/7471

Datasets	Data Source	Temporal Coverage
Tropical Rainfall Measuring Mission (TRMM)	NASA http://trmm.gsfc.nasa.gov/	1998– present
AVHRR land NDVI	NASA http://glcf.umiacs.umd.edu/data/gimms/	1989–present, 1982–present
NCEP Global Reanalysis 2	NOAA http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis2.html/	1948–present
North American Regional Reanalysis	NOAA http://www.emc.ncep.noaa.gov/mmb/rreanl/	1979–present
ECMWF Reanalysis	ECMWF http://www.ecmwf.int/	1979–present
MODIS Land	NASA https://lpdaac.usgs.gov/	2002–2012
MODIS Ocean	NASA http://oceancolor.gsfc.nasa.gov/	
MODIS Snow	NASA http://modis-snow-ice.gsfc.nasa.gov/	
Ocean productivity	http://www.science.oregonstate.edu/ocean.productivity/	1997–2009
ASTER GDEM	USGS http://asterweb.jpl.nasa.gov/gdem.asp	
SRTM	NASA http://www.cgiar-csi.org/data/srtm-90m-digital-elevation-database-v4-1/	
GlobCover	ESA http://dup.esrin.esa.it/prjs/prjs68.php	2009
Socioeconomic data	http://sedac.ciesin.columbia.edu/gpw/global.jsp	1990–2010
Ocean Surface Current Reanalysis (OSCAR)	NASA http://www.oscar.noaa.gov/	1993–present
ETOPO1	NASA http://www.ngdc.noaa.gov/mgg/global/global.html/	1940–2008

Additional Resources

List of Resources

- AniMove (www.AniMove.org)
  - Two-week intensive training course for studying animal movement
- EcoSens: Remote Sening and GIS in Ecology and Conservation (www.ecosens.org)
  - Applied RS and GIS training for conservation and ecology
- Book: "Remote Sensing and GIS for Ecologists" (http://book.ecosens.org)
- Book: "Analysis and mapping of animal movement in R" (Amazon.com)

Live Demo: Life Mapper

http://lifemapper.org/

Coming up next week!

Near Real-Time Monitoring

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Please complete the webinar survey after Week 5!!!!

This image shows the migration routes for white storks. This is part of a large project to determine the effects of migration strategies on survival and fitness (PI: Wolfgang Fielder)

Thank You!!

Cindy Schmidt

Cynthia.L.Schmidt@nasa.gov